WHAT IS CLAIMED IS:

1. A method of forming a waveguide structure, comprising:

forming a first graded layer on a substrate, the first graded layer comprising silicon, germanium, and a lattice constant adjusting material, wherein concentrations of germanium and the lattice constant adjusting material increase with the height of the first graded layer; and

forming a second graded layer above the first graded layer, the second graded layer comprising silicon, germanium, and the lattice constant adjusting material, wherein concentrations of germanium and the lattice constant adjusting material decrease with the height of the second graded layer.

2. The method of claim 1, further comprising:

forming a uniform layer on the first graded layer before forming the second graded layer, the uniform layer comprising silicon, germanium, and the lattice constant adjusting material, wherein concentrations of germanium and the lattice constant adjusting material remain substantially constant throughout the uniform layer.

3. The method of claim 1 wherein the lattice constant adjusting material is carbon.

4. The method of claim 3 wherein the germanium and carbon concentrations in the first graded layer increase linearly with height.

5. The method of claim 3 wherein the germanium concentration in the first graded layer increases from about 0% germanium to about 2-5% germanium at a rate between about 0.1% per μm to about 10% per μm, and the carbon concentration at any point in the first graded layer is about 10% of the germanium concentration.

6. The method of claim 3 wherein the germanium concentration in the first graded layer increases from about 0% germanium to about 2% germanium at a rate of about 10 % per μm, and the carbon concentration at any point in the first graded layer is about 10% of the germanium concentration.

7. The method of claim 3 wherein the germanium and carbon concentrations in the second graded layer decrease linearly with height.

8. The method of claim 3 wherein the germanium concentration in the second graded layer decreases from about 2-5% germanium to about 0% germanium at a rate between about 0.1% per μm to about 10% per μm, and the carbon concentration is about 10% of the germanium concentration.

9. The method of claim 3 wherein the germanium concentration in the second graded layer decreases from about 2% germanium to about 0% germanium at a rate of about 10% per μm, and the carbon concentration at any point in the first graded layer is about 10% of the germanium concentration.

10. The method of claim 3 wherein the germanium concentration in the uniform layer is in the range of about 2 - 5 %, and the carbon concentration in the uniform layer is about 10% of the germanium concentration.

11. The method of claim 3 wherein the germanium concentration in the uniform layer is approximately 2%, and the carbon concentration in the uniform layer is about 10% of the germanium concentration.

12. The method of claim 2 wherein the thickness of the uniform layer is about 2-5 μm.

13. The method of claim 2 further comprising forming a blocking layer on the substrate prior to forming the first graded layer such that the blocking layer is between the substrate and the first graded layer and prevents contaminants in the substrate from diffusing into the first, the uniform, or the second graded layers.

14. The method of claim 13 wherein the substrate is a silicon substrate and the blocking layer comprises epitaxial silicon.

15. The method of claim 2, wherein the substrate has an etched pattern, and the method further comprises:

planarizing the uniform layer prior to forming the second graded layer.

16. The method of claim 2 further comprising forming a cladding layer on the second graded layer.

17. The method of claim 16 wherein the cladding layer comprises epitaxial silicon.

18. The method of claim 2 wherein the first, the uniform, and the second graded layers are formed by chemical vapor deposition processes.

19. The method of claim 18 wherein the first, the uniform, and the second graded layers are formed epitaxially.

20. The method of claim 19 wherein the chemical vapor deposition processes are low pressure chemical vapor deposition processes.

21. The method of claim 18 wherein the chemical vapor deposition process for forming the first, second or uniform layer comprises

determining desired Ge concentration profile and desired layer thickness;

determining flow rates of a plurality of gases; and

introducing into the deposition chamber the plurality of gases according to the determined flow rates while maintaining a pre-determined pressure and temperature in the deposition chamber.

22. The method of claim 21 wherein the plurality of gases comprise a first gas selected from the group consisting of silane, disilane, trisilane, dichlorosilane, and trichlorosilane, a second gas selected from the group consisting of germane, germane in hydrogen, digermane, and digermane in hydrogen, and a third gas selected from the group consisting of methylsilane, and methylsilane in hydrogen.

23. The method of claim 21 wherein the chemical vapor deposition process further comprises

adjusting the flow rates of the second and third gases during the growth of the first and the second graded layer.

24. The method of claim 21 wherein determining the flow rates of a plurality of gases further comprises:

obtaining experimental data of germanium concentration as a function of the flow rate of a first gas among the plurality of gases;

obtaining experimental data of carbon concentration as a function of the flow rate of a second gas among the plurality of gases; and

calculating the flow rates of the first and second gases based on the obtained experimental data and the desired concentration profile.

25. The method of claim 24, wherein the experimental data of germanium and carbon concentrations are obtained by experimental measurements on films formed on test wafers and curve fitting.

26. The method of claim 1 wherein a portion of the substrate is covered with a layer of film and the first graded layer is selectively deposited on a selected portion of the substrate not covered by the layer of film.

27. The method of claim 26 wherein the substrate is a silicon substrate and the layer of film comprises oxide or nitride.

28. The method of claim 2 wherein a portion of the uniform layer and the first graded layer is etched away prior to the formation of the second graded layer.

29. The method of claim 2 wherein the waveguide structure is planar.

30. A method of forming a waveguide structure, comprising:

providing a substrate having an etched pattern;

forming a uniform layer on the substrate such that the uniform layer fills the etched pattern, the uniform layer containing silicon, germanium and a lattice constant adjusting material wherein concentrations of germanium and the lattice constant adjusting material remain substantially constant in the uniform layer; and

planarizing the uniform layer.

31. The method of claim 30 wherein the lattice constant adjusting material is carbon.

32. The method of claim 31 wherein the germanium concentration in the uniform layer is in the range of about 2 - 5 %, and the carbon concentration in the uniform layer is about 10% of the germanium concentration.

33. The method of claim 32 wherein the germanium concentration in the uniform layer is approximately 2%, and the carbon concentration in the uniform layer is about 10% of the germanium concentration.

34. The method of claim 31 wherein the thickness of the uniform layer is in the range of about 2-5 μm.

35. The method of claim 31 wherein the uniform layer is formed on a first graded layer formed in the etched pattern of the substrate prior to the formation of the uniform layer, the first graded layer comprising silicon, germanium and carbon wherein the germanium and carbon concentrations increase with the height of the first graded layer while the carbon concentration remains in proportion to the germanium concentration.

36. The method of claim 35 wherein the germanium and carbon concentrations in the first graded layer increase linearly while the carbon concentration remains in proportion to the germanium concentration.

37. The method of claim 31 further comprising:

forming a second graded layer on the uniform layer, the second graded layer comprising silicon, germanium and carbon wherein the germanium and carbon concentrations

decrease with the height of the first graded layer while the carbon concentration remains in proportion to the germanium concentration.

38. The method of claim 37 wherein the germanium and carbon concentrations in the second graded layer decrease linearly while the carbon concentration remains in proportion to the germanium concentration.

39. The method of claim 30 wherein a blocking layer is formed on the substrate prior to the formation of the uniform layer.

40. The method of claim 39 wherein the blocking layer is epitaxial silicon.

41. The method of claim 31 further comprising forming a cladding layer on the uniform layer.

42. The method of claim 41 wherein the cladding layer is epitaxial silicon.

43. The method of claim 31 wherein the uniform layer is formed by a chemical vapor deposition process.

44. The method of claim 43 wherein the uniform layer is formed epitaxially.

45. The method of claim 43 wherein the chemical vapor deposition process is a low pressure chemical vapor deposition process.

46. The method of claim 43 wherein the chemical vapor deposition process comprises determining desired germanium and carbon concentration for the uniform layer; determining flow rates of a plurality of gases; and

introducing into the deposition chamber the plurality of gases according to the determined flow rates while maintaining a pre-determined pressure and temperature in the deposition chamber.

47. The method of claim 46 wherein the plurality of gases comprise a first gas selected from the group consisting of silane, disilane, trisilane, dichlorosilane, and trichlorosilane, a second gas selected from the group consisting of germane, germane in hydrogen, digermane, and digermane in hydrogen, and a third gas selected from the group consisting of methylsilane, and methylsilane in hydrogen.

48. The method of claim 47 wherein determining the flow rates of a plurality of gases further comprises:

obtaining experimental data of germanium concentration as a function of the flow rate of a first gas among the plurality of gases;

obtaining experimental data of carbon concentration as a function of the flow rate of a second gas among the plurality of gases; and

calculating the flow rates of the first and second gases based on the obtained experimental data and the desired germanium and carbon concentrations.

49. The method of claim 48, wherein the experimental data of germanium and carbon concentrations are obtained by experimental measurements on films formed on test wafers and curve fitting.

50. A method of forming a waveguide structure, comprising

providing a substrate, a first portion of the substrate being covered by a layer of material different from that of the substrate; and

selectively depositing a uniform SiGeC layer on a second portion of the substrate not covered by the layer of material.

51. The method of claim 50, wherein at least the second portion of the substrate is covered by a blocking layer prior to the deposition of the uniform layer.

52. The method of claim 50 wherein the selectively depositing step further comprises:

providing a plurality of deposition gases for depositing a SiGeC layer;

providing at least one etchant gas for removing the SiGeC layer as it is being deposited; and

wherein the SiGeC layer is being removed faster than it is deposited on the first portion of the substrate, and the SiGeC layer is being deposited faster than it is removed on the second portion of the substrate.

53. The method of claim 52 wherein the plurality of depositing gases comprise a first gas selected from the group consisting of silane, disilane, trisilane, dichlorosilane, and trichlorosilane, a second gas selected from the group consisting of germane, germane in hydrogen, digermane, and digermane in hydrogen, and a third gas selected from the group consisting of methylsilane, and methylsilane in hydrogen.

54. The method of claim 52 wherein the at least one etchant gas comprises hydrogen chloride.

55. The method of claim 50 wherein the waveguide structure is planar.

56. A computer readable medium comprising computer executable program instructions that when executed cause a digital processing system to perform a method comprising:

receiving desired germanium and carbon concentration profiles for a SiGeC layer;

determining flow rates of a plurality of gases; and

introducing into a deposition chamber the plurality of gases according to the determined flow rates while maintaining a pre-determined pressure and temperature in the deposition chamber.

57. The computer readable medium of claim 56 wherein the computer program instructions for determining the flow rates of the plurality of gases when executed cause a digital processing system to perform a method comprises:

receiving experimental data of germanium concentration as a function of the flow rate of a germanium gas among the plurality of gases;

receiving experimental data of carbon concentration as a function of the flow rate of a carbon gas among the plurality of gases; and

calculating the flow rates of the germanium and carbon gases based on the received experimental data and the desired germanium and carbon concentration profiles.

58. The computer readable medium of claim 56 wherein the computer program instructions when executed cause a digital processing system to perform a method further comprising:

receiving experimental data of SiGeC film growth rate as a function of the flow rates of the plurality of gases;

determining a thickness of a portion of the SiGeC layer formed in a time interval; and

adjusting the flow rates of at least some of the plurality of gases according to the determined thickness, and the desired germanium and carbon concentration profiles.

59. A waveguide made by a process comprising the steps of:

forming a first graded layer on a substrate, the first graded layer comprising silicon, germanium, and carbon, wherein concentrations of germanium and carbon increase with the height of the first graded layer;

forming a uniform layer on the first graded layer, the uniform layer comprising silicon, germanium, and carbon; and

forming a second graded layer on the uniform layer, the second graded layer comprising silicon, germanium, and carbon, wherein concentrations of germanium and carbon decrease with the height of the first graded layer.

60. A waveguide made by a process comprising the steps of:

providing a substrate having an etched pattern;

forming a uniform layer on the substrate such that the uniform layer fills the etched pattern, the uniform layer containing silicon, germanium and carbon wherein concentrations of germanium and carbon remain constant in the uniform layer; and

planarizing the uniform layer.

61. A waveguide made by a process comprising the steps of:

providing a substrate, a first portion of the substrate being covered by a layer of material different from that of the substrate; and

selectively depositing a uniform SiGeC layer on a second portion of the substrate not covered by the layer of material.

62. A waveguide structure comprising:

a first graded layer on a substrate, the first graded layer comprising first, second and third optical materials, the first material being silicon, the second material being an index of refraction adjusting material and the third material being a lattice constant adjusting material, wherein concentrations of the second and third materials increase with the height of the first graded layer; and

a second graded layer on the uniform layer, the second graded layer comprising the first, second and third optical materials, wherein concentrations of the second and third materials decrease with the height of the second graded layer.

63. The waveguide structure of claim 62 wherein the second optical material is germanium.

64. The waveguide structure of claim 63 wherein the third optical material is carbon.

65. The waveguide structure of claim 62 wherein the concentrations of the second and third materials increase monotonically in the first graded layer and decrease monotonically in the second graded layer.

66. The waveguide structure of claim 62 wherein the concentrations of the second and third materials increase linearly in the first graded layer and decrease linearly in the second graded layer.

67. The waveguide structure of claim 62 further comprising:

a uniform layer between the first graded layer and the second graded layer, the uniform layer comprising the first, second and third optical materials at substantially constant concentration throughout the uniform layer.

68. The waveguide structure of claim 67 wherein the second optical material is germanium.

69. The waveguide structure of claim 67 wherein the third optical material is carbon.

70. A waveguide structure comprising:

a substrate having an etched pattern; and

a uniform layer filling the etched pattern, the uniform layer comprising silicon, germanium, and a lattice constant adjusting material, wherein the concentrations of germanium and the lattice constant adjusting material remain substantially constant throughout the uniform layer.

71. The wavequide structure of claim 70 wherein the lattice constant adjusting material is carbon.

72. The waveguide structure of claim 70 further comprising:

a blocking layer between the uniform layer and the substrate.

73. The waveguide structure of claim 72 wherein the blocking layer is epitaxial silicon.

74. The waveguide structure of claim 70 further comprising:

a clading layer covering the uniform layer.

75. The waveguide structure of claim 74 wherein the clading layer is epitaxial silicon.